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PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Electrical Device Enclosure and Method

We, CORNING GLASS WORKS, a corporation organised under the laws of the State of New York, United States of America, of Corning, New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an enclosure for an electrical device and a method of manufacturing the same. The invention is particularly but not exclusively a method of forming a hermetic seal about a thin film microcircuit without deleteriously affecting the circuit components.

According to one aspect of the present invention, there is provided a method of enclosing an electrical device, the method comprising the steps of:—

(a) providing a dielectric substrate having the electrical device disposed thereon,

(b) providing a metallic ring having two opposite surfaces,

(c) applying an adherent film of vitreous material having a different composition from the dielectric substrate to one of said opposite surfaces, said vitreous material having a coefficient of thermal expansion which is matched with that of said substrate and a softening temperature less than the melting temperature of the substrate and ring materials,

(d) disposing said ring on the substrate surrounding the electrical device with said film adjoining said substrate to form an assembly,

(e) applying heat and pressure to said assembly to fuse said film to said substrate forming a hermetic seal between said ring and said substrate,

(f) disposing a metallic sheet on the other of said opposite surfaces of said ring, and

(g) thereafter hermetically bonding said sheet to said ring at a temperature less than 250°C. at the electrical device.

According to another aspect of the present invention, there is provided an enclosed electrical device comprising:—

(a) a dielectric substrate having the electrical device disposed thereon,

(b) a metallic ring having two opposite surfaces,

(c) a bond between said ring and said substrate comprising a film of vitreous material having a different composition from the dielectric substrate fused to both said substrate and one of said opposite surfaces, said vitreous material having a coefficient of thermal expansion which is matched with that of said substrate and a softening temperature less than the melting temperature of the substrate and ring materials, and

(d) a metallic sheet hermetically bonded to the other of said opposite surfaces of said ring.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made by way of example to the accompanying drawings which show preferred embodiments of the invention, and in which:—

Figure 1 is an exploded perspective view of the components which comprise the enclosure of the present invention,

Figure 2 is a side elevation illustrating bonding of a metallic ring to a dielectric substrate,

Figure 3 is a perspective view illustrating the adjustment of the value of resistance of a film resistor prior to encapsulation,

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Figure 4 is a side elevation illustrating encapsulation of an electrical device, and

Figure 5 is a plan view of an electrical device encapsulated in accordance with the present invention.

For the purposes of simplicity this invention will be described in terms of encapsulating a thin film microcircuit although, as will be readily understood by one familiar with the art, other devices can be similarly hermetically encapsulated.

Referring to Figure 1, a thin film microcircuit unit 10 is illustrated having circuit contact plates 12 and 14, and a thin film resistor 16 formed on substrate 18. Film resistor 16 is formed with a resistance value less than that ultimately desired by leaving a portion 20 of the resistance film unpatterned so that the length to width ratio of the total resistance path may thereafter be increased to provide the resistance value desired. The resistance film may be formed of metallic oxides or the like. For a clear understanding of such resistance films, their characteristics, and one example of their application, reference is made to U.S. Patents Nos. 2,564,706 and 2,564,707 issued to John M. Mochel. The method of forming such circuits do not from part of the present invention and any suitable method, known to one familiar with the art, may be employed. The substrate materials may be any suitable dielectric material such as alumina, glass, ceramic, glazed metals, glazed ceramic, devitrified glass, or a combination thereof and one familiar with the art can readily select a suitable substrate.

A metallic ring 22 having an adherent film or coating 24 of vitreous glazing material is also shown in Figure 1. A particularly suitable material for ring 22 is aluminium. However, other materials such as copper, nickel and stainless steel may be used. The vitreous glazing material may be sprayed on in molten form, applied as a frit and then fired or adhered to the metallic ring by other conventional means, and one familiar with the art can readily select a suitable method for applying the glazed coating. The vitreous glazing material must have a coefficient of thermal expansion which is matched with that of the substrate material, that is sufficiently close to that of the substrate material so that when the coated ring is sealed to the substrate excessive stresses will not be set up within the glazing material upon cooling. Such excessive stresses cause the glazing material to check or crack making a hermetic seal impossible. In addition, the glazing material must adhere well to both the ring of substrate, and must have a high resistivity and low dielectric constant. The preferred material for sheet 26 is aluminium. However, other materials sealable to ring 22, such as the materials listed for ring 22, may also be used. A metallic cover plate 26 is shown disposed adjacent ring 22. The opposite faces of the plate 26 and the ring 22 are flat in the illustrated embodiment.

Examples of some suitable glazing material compositions include those of the type described in our copending Patent Applcation No. 40638 of 1965 (Serial No. 1,078,328). These compositions comprise, in per cent by weight on an oxide basis, from 60% to 80% PbO, from 5% to 18% TiO_2, at least 1% B_2O_3, and at least 5% SiO_2, the total B_2O_3 and SiO_2 being from 10 to 20%. These compositions may optionally comprise from a trace up to 20% of at least one of the divalent metal oxides BaO and ZnO, the total of the divalent metal oxides, including PbO, being from 60% to 80%. Compositions especially suitable for the present purposes are those containing from 10% to 13% of TiO_2.

Referring to Figure 2, microcircuit unit 10 is shown disposed on an anvil or rigid support 28 with ring 22 and its adherent coating 24 placed adjacent the microcircuit side of substrate 18. A heated tool 30 is caused to contact ring 22 and exert a force in the direction of the arrow shown, fusing coating 24 to substrate 18 and contact plates 12 and 14. Such fusing forms a hermetic seal between ring 22 and microcircuit unit 10. Tool 30 may be heated by any method well known in the art, such as for example, induction heating. When desired, support 28 may be suitably cooled to remove some of the heat conducted to substrate 18 during the fusing process thereby minimizing any deleterious effects to the microcircuit element which may result from excessive heating.

After the fusing step, the values of the electrical properties of the circuit elements may be adjusted, as for example, by increasing the length to width ratio of resistor 16 by removing part of unpatterned portion 20 of the resistance film with a precision sand blast stream produced by nozzle 32, as illustrated in Figure 3. It is also contemplated, that the circuit elements may be formed on substrate 18 or attached to a partially applied circuit at this time. Transistors, capacitors, and the like are examples of suitable electrical components which may be attached to partially formed circuits.

After the circuit is suitably adjusted or compensated and all elements are attached thereto, it is in condition for final encapsulation as illustrated in Figure 4. The assembly as described in connection with Figure 3 is placed on an anvil or rigid support 34. Sheet 26 is placed on ring 22 and an ultrasonic bonding tool 36 is brought in contact therewith. Sheet 26 is then hermetically cold bonded to ring 22 by means of ultrasonic energy in a manner well known in the art. Such ultrasonic bonding does not significantly raise the temperature of the device. Other methods of forming a cold bond may

also be used, as for example, soldering, welding, diffusion bonding, and the like. By a cold bond is meant one that is formed at a temperature less than about 250°C. at the device. In the two step encapsulation method of the present invention any deleterious effects to the device elements brought about by the fusion of coating 24 to unit 10 are removed during the adjustment or compensation step prior to the cold bonding encapsulation step, thereby resulting in an electrical device having the precise electrical values desired.

Figure 5 illustrates a completed device 38. Contact plates 12 and 14 are shown extending beyond the edges of sheet 26 so that contact may be made with the encapsulated circuit element.

A typical example of this invention is illustrated by the following. Vitreous glazing material having a thickness of about 5 mils and comprising by weight of about 68% PbO, 12% TiO_2, 8% SiO_2, 5% ZnO, and 7% B_2O_3 was adherently applied to one mating surface of an aluminium ring having a thickness of about 3 mils, forming a coating thereon. The glaze was applied by forming a layer of a frit of the material on the mating surface and thereafter firing the composite structure in a furnace at 620°C. for 20 minutes. A metallic oxide film resistor, having a resistance value less than that ultimately desired, together with silver contact plates, was applied to a glazed alumina substrate. A low resistance was obtained by leaving a portion of the film unpatterned.

The substrate was placed on a rigid support and the coated ring was disposed thereon surrounding the film resistor with the coated surface adjacent the substrate. A pressing tool was inductively heated to a temperature of from about 500°C. to 550°C. and brought into contact with the aluminium ring. A pressure of about 285 PSI was applied by the tool to the assembly so formed for about two minutes by means of a press connected to the tool. The resistance of the film resistor was thereafter measured and the length to width ratio of the film increased by cutting a groove in the unpatterned portion thereof with a sandblast stream. When the desired value of resistance was reached, the cutting was stopped, the assembly was placed on a rigid support, and a sheet of aluminium having a thickness of about 3 mils was disposed on a second mating surface of the aluminium ring. An ultrasonic bonding tool was then brought in contact with the sheet, ultrasonically bonding it to the ring thereby forming a hermetic seal therebetween.

The resulting encapsulated device was found to be hermetically sealed and to have predetermined desired values of electrical properties and characteristics.

Another example of the present invention is illustrated by an assembly wherein the substrate was formed of beryllia, a 5 mil thickness of vitreous material glaze was applied to a 3 mil thick copper ring, and a 3 mil thick copper cover sheet was provided.

Other examples of particularly suitable combinations of materials are an aluminium ring and cover sheet with a substrate of unglazed alumina, beryllia, glass, or devitrified glass; and a copper ring and cover sheet with a substrate of devitrified glass, or glazed or unglazed alumina.

WHAT WE CLAIM IS:—

1. A method of enclosing an electrical device, the method comprising the steps of:—

(a) providing a dielectric substrate having the electrical device disposed thereon,

(b) providing a metallic ring having two opposite surfaces,

(c) applying an adherent film of vitreous material having a different composition from the dielectric substrate to one of said opposite surfaces, said vitreous material having a coefficient of thermal expansion which is matched with that of said substrate and a softening temperature less than the melting temperature of the substrate and ring materials,

(d) disposing said ring on the substrate surrounding the electrical device with said film adjoining said substrate to form an assembly,

(e) Applying heat and pressure to said assembly to fuse said film to said substrate forming a hermetic seal between said ring and said substrate,

(f) disposing a metallic sheet on the other of said opposite surfaces of said rings, and

(g) thereafter hermetically bonding said sheet to said ring at a temperature less than 250°C. at the electrical device.

2. A method according to claim 1, further comprising the steps of adjusting the value of an electrical property of said device to a predetermined value, after forming the hermetic seal between said ring and said substrate and prior to disposing said sheet on said ring.

3. A method according to claim 1 or 2, wherein said sheet is sealed to said ring by ultrasonic energy.

4. A method according to any preceding claim, wherein said vitreous material comprises, in per cent by weight, from 60% to 80% PbO, from 5% to 18% TiO_2, at least 1% B_2O_3, and at least 5% SiO_2, the total of B_2O_3 plus SiO_2 being from 10% to 20%.

5. A method according to claim 4, wherein said vitreous material further comprises, in per cent by weight, from a trace to 20% of at least one of the divalent metal oxides BaO and ZnO, the total of divalent metal oxides, including PbO, being from 60% to 80%.

6. A method according to claim 4 or 5, wherein the proportion of TiO_2 in said

vitreous material is from 10% to 13% by weight.

7. A method according to any preceding claim, wherein said substrate is of alumina.

8. A method according to any preceding claim, wherein said ring is of aluminium.

9. A method according to any preceding claim, wherein said sheet is of aluminium.

10. A method according to any preceding claim, wherein said substrate, said opposite surfaces of said ring and said sheet are flat.

11. A method of forming an enclosure, the method comprising the steps of:—

(a) providing a dielectric substrate,

(b) providing a metallic ring having two opposite surfaces,

(c) applying an adherent film of vitreous material having a different composition from the dielectric substrate to one of said opposite surfaces, said vitreous material having a coefficient of thermal expansion which is matched with that of said substrate and a softening temperature less than the melting temperature of the substrate and ring materials,

(d) disposing said ring on the substrate with said film adjoining the substrate to form an assembly,

(e) applying heat and pressure to said assembly to fuse said film to said substrate forming a hermetic seal between said ring and said substrate.

(f) disposing a metallic sheet on the other of said opposite surfaces of said ring, and

(g) thereafter bonding said sheet to said ring at a temperature less than 250°C.

12. A method of enclosing an electrical device, substantially as hereinbefore described with reference to the accompanying drawings.

13. An enclosed electrical device comprising:—

(a) a dielectric substrate having the electrical device disposed thereon,

(b) a metallic ring having two opposite surfaces,

(c) a bond between said ring and said substrate comprising a film of vitreous material having a different composition from the dielectric substrate fused to both said substrate and one of said opposite surfaces, said vitreous material having a coefficient of thermal expansion which is matched with that of said substrate and a softening temperature less than the melting temperature of the substrate and ring materials, and

(d) a metallic sheet hermetically bonded to the other of said opposite surfaces of said ring.

14. An enclosed electrical device according to claim 13, wherein said substrate is of alumina.

15. An enclosed electrical device according to claim 13 or 14, wherein said ring is aluminium.

16. An enclosed electrical device according to claim 13, 14 or 15, wherein said sheet is of aluminium.

17. An enclosed electrical device according to any one of claims 13 to 16, wherein said substrate, said opposite surfaces of said ring and said sheet are flat.

18. An enclosed electrical device according to any one of claims 13 to 17, wherein said vitreous material comprises, in per cent by weight, from 60% to 80% PbO, from 5% to 18% TiO_2, at least 1% of B_2O_3, and at least SiO_2, the total of B_2O_3 plus SiO_2 being from 10% to 20%.

19. An enclosed electrical device according to claim 18, wherein said vitreous material further comprises, in per cent, by weight, from a trace to 20% of at least one of the divalent metal oxides BaO and ZnO, the total of divalent metal oxides, including PbO, being from 60% to 80%.

20. An enclosed electrical device according to claim 18 or 19, wherein the proportion of TiO_2 in said vitreous material is from 10% to 13% by weight.

21. An enclosure comprising:—

(a) a dielectric substrate,

(b) a metallic ring having two opposite surfaces,

(c) a bond between said ring and said substrate comprising a film of vitrous material having a different composition from the dielectric substrate fused to both said substrate and one of said opposite surfaces, said vitreous material having a coefficient of thermal expansion which is matched with that of said substrate and a softening temperature less than the melting temperature of the substrate and ring materials, and

(d) a metallic sheet hermetically bonded to the other of said opposite surfaces of said ring.

22. An enclosed electrical device substantially as hereinbefore described with reference to the accompanying drawings.

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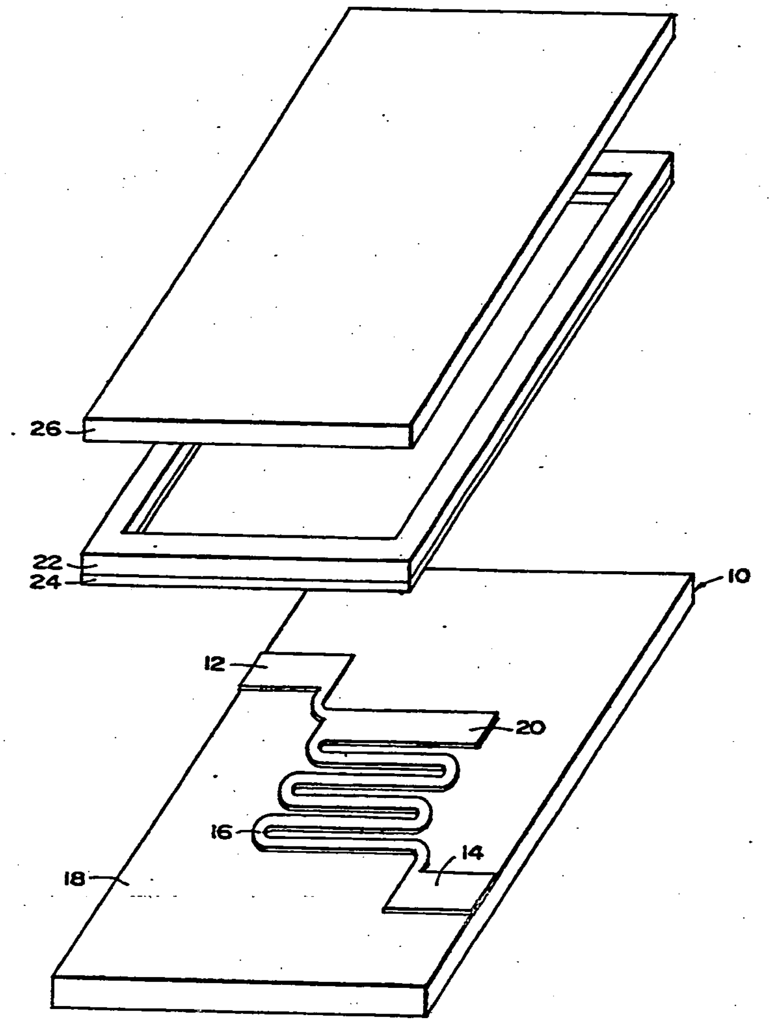


FIG.1

FIG.2

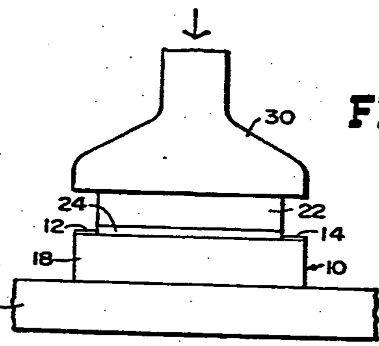


FIG.4

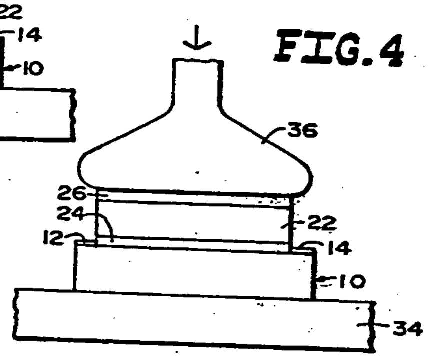
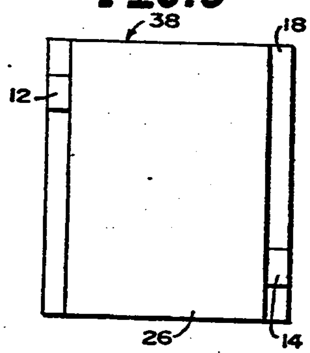


FIG.5



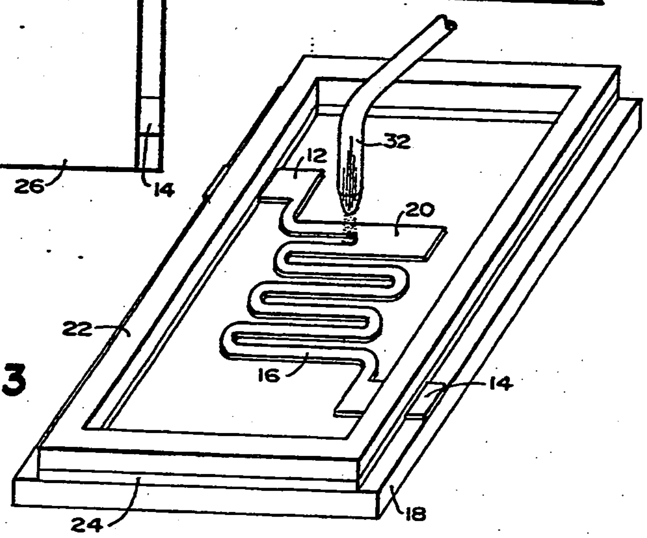


FIG.3